MINISTRY OF
AGRICULTURE, FISHERIES AND FOOD

COMMITTEE ON SHEEP RECORDING AND PROGENY TESTING

Report to
The Chairman, Agricultural Improvement Council
for England and Wales and
The Chairman, Scottish Agricultural Improvement Council

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Committee on Sheep Recording and Progeny Testing

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COMMITTEE ON SHEEP RECORDING AND PROGENY TESTING
REPORT to
The Chairman, Agricultural Improvement Council for England and Wales
and
The Chairman, Scottish Agricultural Improvement Council

Sirs,

We were appointed to be a Committee in May, 1959, with the terms of reference:

> "To review the present position in regard to sheep recording and progeny testing; and to recommend what further developments are now desirable."

We suffered a severe loss through the death in January, 1960, of one of our colleagues, Mr. George Hedley, O.B.E. At the stage we had then reached in our work it was considered unnecessary to appoint a replacement for him; otherwise our membership has remained unchanged.

We met eighteen times in London and once in Edinburgh. On the latter occasion we visited the Animal Breeding Research Organization of the Agricultural Research Council, when the geneticists' approach to sheep breeding was described to us.

We have not found it necessary to take independent evidence about sheep recording and testing activities in this country. We had the benefit of a report by the Ministry's National Agricultural Advisory Service on this subject, which we accepted as comprehensive, and our membership includes persons closely associated with the organized sheep recording schemes at present in existence here. Our scientist members have been able to bring to our attention the results of sheep investigations at research organizations in this country.

We are indebted to the Commonwealth Bureau for Animal Breeding and Genetics for information about sheep recording and breeding activities overseas, and to the Agricultural Attaché in the United States, and Advisers in Australia and New Zealand for references to such work in their respective countries. In addition, the Chairman visited the University of Wisconsin to get first-hand details of the Sheep Recording Scheme organized there since 1949.

Finally we would like to express our sincere appreciation of the work of our secretaries. Theirs was not an easy task, owing to the complexity of the subject of our enquiry; and our thanks are due especially to Mr. F. J. S. Culley, whose unfailing helpfulness and efficiency in carrying out his exacting duties were of the utmost assistance to us throughout our enquiry and in the preparation of our report. We are also indebted to Mr. R. J. Gayton, who acted as our technical secretary during the first half of our enquiry, until pressure of other duties precluded his continuance, and to Mr. T. J. C. David, who most ably performed similar duties as his successor.

We now submit our report.

We have the honour to be, Sirs,
Your obedient servants,
Ivor R. Morris (*Chairman*)

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C. J. Chilman
W. R. Merricks
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February, 1961

COMMITTEE ON SHEEP RECORDING AND PROGENY TESTING REPORT

Chapter 1: Introduction

1. The Committee was formed by the Agricultural Improvement Councils of England and Wales and of Scotland, with the support of the National Sheep Breeders' Association, after the publication of the report "The Sheep Industry in Britain, 1958" of the Natural Resources (Technical) Committee set up by the Lord President of the Council. In that report, it was stressed that very little was being done by those in the sheep industry to take advantage of the techniques of recording and progeny testing, and that the industry in fact was dependent on pedigree breeders whose objectives and methods were in some respects out of date. Accordingly, the recommendation was made that more attention should be given to the commercial performance of ewes and rams and that to this end recording and progeny testing should be encouraged.

2. During the last twenty years the estimated gross output of British agriculture has, on a fixed price basis, risen by more than one half. Sheep during this period have receded and then recovered in numbers and although they are now contributing relatively a little less to total agricultural output than before the war, they must be subject to the general intensification of farming. On lowland farms in particular the improved pastures, heavy fertilizer applications and better methods of controlling disease have changed substantially the environments in which sheep are produced. These developments in husbandry, together with changes in market requirements and rising wages, call for a review of our methods of breeding for adaptation to the new conditions.

3. Against this background we have studied the practical aspects of recording and progeny testing when applied to sheep in Britain. For the purposes of our remit we have regarded recording as the process of keeping written records, whether simple or complex, to provide information relevant to management or breeding problems and progeny testing as a generic term for all methods of forming a judgment on the breeding merit of an animal by reference to its close relatives whether they be offspring, or sibs and half-sibs (that is full or half brothers and sisters).

4. The question whether recording and family selection will be worth while for any particular breeder depends of course on his outlook and objectives. Some breeders, particularly those who are more concerned with appearance and "breed points" than with performance, will feel that they cannot derive sufficient advantage from recording to offset the trouble and cost. To record but not be guided by the records is a waste of effort. Other breeders, disposed to think more of productivity than of appearance, will find records indispensable. We believe that more attention should be paid in sheep breeding to such matters as prolificacy, milking capacity, growth rate, fleece weight, and carcass quality and it is with this in mind that our recommendations are made.

5. It is a feature of sheep breeding, as of pig and cattle breeding, that comparatively few rams in each breed provide the bulk of the males for the so-called multipliers' flocks. As a result of this stratification, only those genetic changes which are brought about in the top flocks are of much long term interest, for they are the only ones with much chance of spreading through a breed. For this reason a rapid spread of the methods advocated in this report is desirable among flocks currently providing breeders' rams.

Chapter 2: The Kinds of Flocks in Britain and their Functions and Attributes

6. The objectives and methods of sheep breeders must take account of the kind of husbandry that is possible in the environments in which the sheep have to live and the purposes for which they are kept. There are marked differences in the composition of flockmasters'

receipts according to the breeds of sheep employed and the systems of management practised. This is illustrated in Appendix 1, which quotes the indications from university surveys that the value of wool in lowland flocks can be expected to comprise about 10–15 per cent of income from sheep; that for upland farms shown as the Scottish stock rearing group it is about 15 per cent; and that on hill farms in Wales and Scotland it is a much higher proportion. In the latter flocks there is again variation between the more prolific flocks in which cross breeding is practised where the value of the wool clip is about 20–25 per cent of income from sheep, and the pure-bred hill flocks where the proportion may be as high as 45 per cent.

7. Before considering ways in which recording and progeny testing might benefit the industry, it is essential to appreciate which are the most important characters in sheep kept in different kinds of flocks. There are about forty recognized pure breeds of sheep in Britain; and there are also many crossbred flocks, representing a considerable number of traditional first crosses, in which the females are used for a further stage of breeding. In terms of their functions in the industry however these purebred and crossbred flocks can be grouped in six basic categories. These are as follows:

a. hill flocks;
b. lowland flocks producing the sires of crossbred ewes;
c. lowland flocks producing their own replacements, females for sale and fat lambs;
d. lowland flocks producing fat lamb sires;
e. lowland flocks producing mutton sires;
f. lowland flocks being developed for lambing out of season and more frequently than once a year.

These basic categories produce all the raw material for the various kinds of commercial flocks kept in this country.

8. Our many hill flocks make use of land that would otherwise be agriculturally unproductive; they also create a reservoir of breeding stock which forms the foundation of the crossbred ewe flocks on the more fertile lowland farms. In hill sheep hardiness is essential and the inevitable development of strains able to rear a crop of lambs on a low plane of nutrition has created a great reputation for the hill ewe as a milker when moved to easier conditions. Fleece weight and quality are important not only to enable the sheep to survive on the hills but also because sales of wool contribute a very substantial proportion of the hill flockmaster's returns. The essential characters in hill sheep are therefore ability to rear a 100 per cent lamb crop, and satisfactory quality and weight of fleece.

9. Whatever the breed of the sire that is used to produce the crossbred ewe, the qualities of the ram are passed on in some measure to a considerable proportion of the commercial lamb-producing flocks in this country. Prolificacy and milking capacity are the two most important qualities influenced by the ram and therefore to be fostered in the flock in which he is bred; the third is growth rate.

10. On many farms in this country purebred flocks are kept to provide their own replacements and females for sale as well as for fat lamb production. This is a most important category of sheep and the essential characteristics to be fostered are prolificacy, milking capacity, growth rate and carcass quality.

11. Those flocks which are breeding fat lamb sires have considerable influence on the success of the commercial flocks in which their rams are used. There is great need to improve the contribution to growth rate from the ram that is siring fat lambs to be marketed direct from their mothers at twelve to sixteen weeks of age. For fat lambs the most important qualities to be influenced by the sire are growth rate and carcass quality.

12. The qualities required in a mutton sire, that is one whose offspring will be sold as hoggets to be slaughtered late in the season, are markedly different from the qualities required in a fat lamb sire. The reason for this is that as a lamb is reared on to a weight above about 40 lb dead weight, the proportion of fat to lean in its carcass can alter. Consequently, the most important contribution from the mutton sire is carcass quality with growth rate next in importance, perhaps together with fleece weight and quality.

13. On suitable farms under the right climatic conditions, and with the development of

early weaning techniques, there may be increasing scope for lambing out of season and more frequently than once a year. The qualities required in these flocks are above-average lambing frequency with reasonable prolificacy and milking capacity. The objective might be to produce 150 per cent lambs at each lambing and three crops of lambs in two years.

14. We have concluded that in lowland flocks the characters of primary economic importance are one or more of the following—prolificacy, milking capacity, growth rate and carcass quality. We realise that in many of these flocks wool is an important and valuable product; and that it may therefore pay the flockmaster to give attention to fleece weight and quality. But we think that to achieve improvements in prolificacy, milking capacity and growth rate and perhaps carcass quality would be difficult enough in practice without further complication; and we think that it has to be left to the individual flockmaster to decide whether, in his particular circumstances, to attempt to improve fleece characteristics as well as the others or in substitution for some of them. In hill flocks emphases are different, the most important characters being hardiness, weight and quality of fleece, and an optimum prolificacy of one lamb per ewe. It must always be remembered, however, that environmental conditions for hill sheep are a severe limiting factor on performance; and enough is not yet known about the various characters to support firm recommendations for breeding objectives.

Chapter 3 : Genetic and Practical Considerations Relative to the Various Characters

REPEATABILITY AND HERITABILITY OF CHARACTERS

15. Each year a flockmaster has to decide which of his females are to be retained for further breeding and, if he is breeding his own replacements, which of the offspring of those females are to be retained for future breeding. These decisions must be taken in relation to one or more characters which the flockmaster considers to be important. In terms of genetics, the flockmaster is concerned with the *repeatability* or the *heritability* of those characters. Repeatability refers to the likelihood that an animal will behave similarly in successive years of its life and has no necessary relationship to what it may breed. Heritability refers to the likelihood that an animal will breed offspring similar to itself. In culling his females the flockmaster is seeking, by reference to their performance to date, to achieve the best possible future performance by those retained; he is then concerned with the repeatability of the desired character or characters. In making his choice of lambs to be retained for future breeding, the flockmaster has to take account of the qualities demonstrated by the lamb and of the attributes it is likely to have inherited from its parents; he is then concerned with the heritability of the character or characters which he considers to be important. In general, it seems that characters which are highly repeatable are also highly heritable, and that those of low repeatability are also of low heritability. But it does not follow that the actual repetition year by year of a character in a particular animal gives an assurance that the character will be inherited by the animal's offspring: the genetic influence of one generation on the next remains conditioned by the heritability of the character concerned. A point of considerable practical importance is that characters of high repeatability and heritability need be measured only once in the lifetime of the animal, since such measurement provides a reliable guide to the animal's performance in relation to that character in future years.

16. Repeatability differs between characters. Such information as is available from genetic studies overseas suggests that among highly repeatable characters are fleece weight, some fleece qualities, body weight, colour and conformation; that non-repeatable or poorly repeatable characters include prolificacy, condition and weaning weight; and that milk production and birth weight probably vary in repeatability from low in hill flocks to moder-

ate in lowland flocks. The validity of this classification for British conditions may have to be modified when more information is available.

17. To illustrate the implications of repeatability, it may be noted that fleece weight tends to be repeated relatively accurately from year to year. Experimental work suggests that in a breed with an average fleece weight of about 4½ lb, a breeder who is in a position to cull 10 per cent of his yearlings and uses the opportunity to get rid of those with the lightest fleeces, would probably raise average fleece weight by one-tenth to one-fifth of a pound over the whole flock. This alone would cover the cost of recording yearling fleece weights. On the other hand, the repeatability of prolificacy appears to be very low; consequently, the regular culling of barren ewes that is widely practised appears to be unjustified from the genetic point of view, although it may be justified on management grounds, for example, the practical difficulty of keeping a barren ewe in proper breeding condition. Culling for characters of low repeatability certainly reduces the scope for paying attention to characters that are more highly repeatable.

18. Heritability also varies between characters, the heritabilities of those of major economic importance being mentioned in later paragraphs.

19. It is essential to appreciate that the lower the repeatability or heritability of a character, the more responsive it is to changes in levels of management. It follows that the less valuable recording is as a guide to culling or to the selection of lambs for breeding, the more valuable it is as an aid to management.

Prolificacy

20. Prolificacy is a character of low heritability. This fact has considerable implications for practice so it is perhaps desirable to elaborate it. If prolificacy had zero heritability, the prolificacy of the chosen parents would make no difference to that of the offspring. If it had 100 per cent heritability, as blood groups have, the prolificacy of the offspring would be wholly determined by that of the chosen parents. Past experience suggests that the actual heritability of prolificacy, at a single lambing, is of the order of 5 per cent when differences of prolificacy among sheep of the same breed are under consideration. The value might be higher for crossbreds. To take a simple example: if the ewes selected for breeding replacements average two lambs weaned in a flock with an average of 1·5 lambs weaned, then at best 5 per cent of the difference (·025 of a lamb) is the improvement to be expected from the female side. If the rams are average (because untested and unknown in this character) then ·025 has to be divided by two. The prolificacy of the new generation will be ·0125 or 1/80 of a lamb per ewe better.

21. By no means all the evidence points to a heritability as low as 5 per cent but the greater weight of evidence does. However, conditions can be imagined where heritability could be higher and some breeders may wish to act on the assumption that in their case selection will be more effective than in the above example. Heritability of prolificacy as measured by three or more lambings will be higher. As a rule, the improvement in heritability is not enough to offset the delay, so that the rate of progress per year declines.

22. Some of the practical aspects of selecting ewes for prolificacy are worth noting:

a. a breeder needs to be clear in his mind what meaning he is going to attach to prolificacy. Lambs born, alive or dead, is one thing; and lambs weaned is another and more complex thing. The former is recommended firstly because the information is obtained early, and secondly because many complicating factors due to disease and accident are excluded;

b. those who breed for higher prolificacy should ensure that the level of husbandry is high enough to exploit the inherent fertility of the stock, particularly in respect of pre-natal nutrition, so that lambs are of good birth weight and well nursed. Ewes with twin lambs are commonly treated rather better than those with singles and this helps to prevent a large difference in weight from developing between twins and singles. These ewes, of course, may come to the next mating season in better breeding condition than the ewes that reared singles and thus start off with a self-perpetuating advantage of a kind not transmitted by breeding;

c. the reason for a low heritability is a highly variable performance. Thus ewes can and do have 0, 1, 2, 3, or even 4 lambs at a time. Because they vary like this, some breeders average their fecundity over several pregnancies to improve the validity of classifying them. Some ewes are bound to appear consistent. In a flock with a lambing percentage of 150, approximately half the ewes will drop twins or triplets. If this half were the result of purely random events, then next year another random half would include one quarter that bad had twins or triplets in both years. In the third year, one eighth, or 12½ per cent, would have twinned three times running purely by chance. If, however, there are, say, 25 per cent of them then one of two explanations is likely. Some ewes may have had a continuing environmental advantage since their first year; or some may have a genetic superiority. There is another possibility; in the third season, not 12½ per cent but fewer, say, only 1–2 per cent, drop twins. If the flock average has not fallen, then this can only mean that ewes with twins in the second season were under-fed or otherwise ill-used.

23. Prolificacy is greatly influenced by environment. In its widest sense, environment includes such things as health and management; and environments rarely remain even substantially unchanged from one generation to the next. Whether a gimmer or ewe has one lamb or more is affected by her age, breed, size, body weight and by the time and frequency of tupping and these factors alone may be of much greater significance than any genetic influence. The fact that a gimmer or ewe has no lamb at all in a particular year may also be due to some temporary physiological defect and have no bearing on likely performance in future years. This places a serious limitation on the value of daughter/dam comparisons and makes it essential that any animals being compared should be kept under apparently identical conditions.

24. Because the improvement of prolificacy is especially difficult, there is no point in attempting it unless breeding animals are selected primarily (solely, if necessary), on this character. To pay much attention to other characters first is tantamount to abandoning the task of changing prolificacy by direct selection.

25. Sometimes it seems that to confine attention to one character is to risk the possibility of deterioration in others. For example, on a constant level of nutrition, it seems inevitable that to breed successfully for more milk must react adversely on meat or wool production. This, however, is perhaps not as inevitable as it may appear at first glance since it is known that efficiency of food utilization shows genetic variation and can be improved. Breeders can also raise the level of nutrition or select for increased body size and so cancel the "loss" that would otherwise occur. Little is known about British breeds of sheep in respect of changes in one trait induced by changes in another and breeders must make their own decisions as best they can. Constructive breeders will need no reminding in such circumstances that nothing ventured will mean nothing gained.

26. We have concluded that any improvement of prolificacy based on genetic factors alone is bound to be a slow process; that much improvement will be retarded if selection is attempted at the same time for other characters; and that the speed at which it can proceed is limited by the selection pressure which can be applied without unduly reducing the size of the breeding flock, or producing a flock with too high a proportion of young females which would in itself tend to depress average prolificacy (see Appendix 2—Age effect on fertility of ewes).

Milking capacity, growth rate and weaning weight

27. These three attributes are closely inter-related. The milk yield of the ewe is the most important influence on the early growth rate of the lamb and marked differences have been found between the milk yields of different breeds and crosses. It has also been found that great differences in yield occur between individual ewes of the same breed or cross. Present evidence points to low heritability of milking capacity, and it follows that so long as the growth rate of lambs is wholly dependent on the milk supplied by their dams the heritability of growth rate will also be low. It also follows that, as with prolificacy, any improvement through genetic selection of the milking capacity of ewes or of the growth rate of young lambs is likely to be slow. As lambs become progressively more independent, their own heredity gradually receives expression. Consequently, although weaning weight will respond but slowly to selection among ewes of unmatched milking capacity (no matter whether it is regarded as a character of the dam or of the lamb), the body weights of shearlings or ewes will have a higher heritability and so respond more quickly.

28. Interdependence of milk yield of ewes and growth rate of lambs is shown clearly by some results from the University College of North Wales. These were obtained in 1954 with 181 hill-bred Welsh mountain ewes rearing single lambs. Once a week the lambs were weighed, just before and after suckling over a period of twenty-four hours. From the weighings, estimates could be made of each ewe's milk production and of each lamb's growth during successive periods of two weeks. As would be expected the higher the milk production went the greater the growth rate of the lamb. Degree of correlation is expressed by a coefficient that reaches a value of 1·0 if the correlation is perfect and a value of 0·0 if there is no tendency at all for the two characters to vary upwards or downwards together. As the following table shows there was a strong correlation of milk and growth for the lambs when very young (coefficient 0·87) and only a weak correlation (coefficient 0·21) when they were eight to ten weeks old.

Lactation period *Weeks*	*Correlation of milk yield and lamb growth*
0– 2	0·87
2– 4	0·76
4– 6	0·51
6– 8	0·42
8–10	0·21

29. The extent to which the growth rate of the lamb indicates the milking capacity of the ewe therefore depends on the period over which growth is measured and on these data growth during the first four weeks after birth gives the most accurate indication. Although this investigation concerned hill sheep, other data suggest that the conclusions are of general validity for lowland breeds as well.

30. At any age after birth the weight of a lamb is dependent on the maternal influence of the dam, on the complex of other environmental conditions, and on the inherent ability of the lamb to grow. Both the sire and dam contribute equally to the lamb's genetic constitution. Although most conspicuous in breed comparisons, genetic differences in lamb weights also occur among lambs of the same breed.

31. Maternal influence, quite apart from the ewe's contribution to the lamb's heredity, is exhibited both before and after the birth of the lamb. Whilst the nature of this influence is not fully understood, some parts of it, for instance the effects of age of ewe, size of ewe and feeding on birth weights and milk production are widely recognized. The high correlation of milk yield and growth of young lambs has been stressed in preceding paragraphs; and although the growth rate of a lamb at say twelve weeks of age has little dependence on the ewe's milk at that time its size is largely determined by the milk it received during the preceding weeks.

32. Substantial though the maternal influence may be, it by no means explains all the variations in weight which breeders will have observed even among the lambs of uniformly treated ewes of the same age and condition. It is this unexplained and uncontrollable variation which makes the improvement of ewe performances, in terms of lamb weight and milk production, slow and difficult. Such is the economic significance of this complex of characters that many breeders will nevertheless feel compelled to undertake the task. As yet there is insufficient information on sheep in Britain on which to base detailed genetic advice on this topic. Even if there were, that advice would probably differ from breed to breed. One permissible generalization however is that within a breed or specific cross, lamb weights up to weaning are mainly determined by the milk production of ewes. A breeder who chooses to regard the improvement of milk production as his main objective will think of lamb weights up to weaning as evidence of ewe performance and will be interested in them as part of his assessment of individual ewes and of groups of half sisters by a common sire. Alternatively, a breeder may regard lamb weights as characters of the lambs themselves and, having made allowance for such variables as sex, litter size and age of dam, will select his replacement breeding stock accordingly. Both lines of thought and action can sometimes be followed at

the same time by first preferring the offspring of certain ewes (e.g., those by particular sires) and then reducing this number by selecting lambs of the highest (corrected) weights. This is more complicated and involves trying to breed, in effect, for milk production and growth rate at the same time.

33. From the foregoing it will be appreciated that, if the effects of maternal influence can be equalized or substantially eliminated, corrected lamb weights become very much more valuable indicators of the lamb's genetic constitution. Indeed in these circumstances lamb weights can be regarded as fairly highly heritable so that the weight of the individual lamb provides a useful guide to its likely contribution to the weight of its progeny at the same age. One way of reducing variations in weights that are due to maternal influence is to breed from ewes of similar milking capacity. A way of tackling this is illustrated in the specimen breeding programme at Appendix 7. Another way is to measure weights after the maternal influence has become remote, i.e., as long as possible after weaning. Experimental work has shown that a lamb's gain in weight over a period of some months after weaning gives a reasonably accurate guide to the lamb's inherent capacity for growth up to weaning; and the measurement therefore also gives a reasonably accurate indication within the same flock of the capacity for early growth that will be transmitted to the lamb's offspring.

34. Experimental work at the Animal Breeding Research Organisation has shown that to a considerable extent differences in weaning weights must be attributed to the sex of the lamb, litter size, and the age of the dam. For purposes of comparison between lambs weaned at fourteen weeks it appeared from five year's results that the following additive correction factors were appropriate:

Corrections for litter size and sex	
For male singles add	0·0 lb
For female singles add	7·0 lb
For male twins add	14·0 lb
For female twins add	20·0 lb
Corrections for age of dam	
For gimmer's lambs add	0·0 lb*
For hogg's lambs add	11·0 lb*
For ewe's lambs deduct	4·0 lb

* The terms hogg and gimmer mean, respectively, females one year old and two years old at lambing time.

These factors were appropriate to a crossbred flock under lowland conditions in which ewe lambs were bred from and to a particular form of management. For other flocks, they may indicate no more than the order of magnitude of the effects of sex, twinning, and age of ewe. Differences in weights are also to be expected between one year and another because of differences in season and management.

35. In making use of weaning weights the existence of these differences due to sex, litter size, age of dam and season must be borne in mind. In the nature of things there can be no set of factors of general validity. In a large flock it may be practicable to make separate comparisons between lambs of the same sex, from the same sized litters and from dams of the same age and so avoid the problem of determining correction factors altogether; and in a small flock experience may indicate approximate correction factors for sex and litter size.

36. Milking capacity, growth rate of young lambs, and weaning weights are of prime economic importance. They are also highly responsive to variations in environment, which fact results in the low repeatability and heritability of milking capacity and of the other characters unless maternal influence can be discounted. Visual appraisal of these characters is not very effective; which indicates that there is the strongest case for recording them to provide a rational basis for seeking improvement in management and a necessary tool in breeding.

Carcass quality

37. This is an important but intractable problem, or rather, set of problems to which

there can be no single solution. As is well known, carcass quality varies with live weight, breed, age, sex and rate of growth. There is no simple way of recognizing it in live sheep; it cannot even be fully assessed in an uncut carcass. Some of the complexities can be avoided by the individual breeder if he works within one breed, and within a narrow range of live weights and growth rates. Still more can be avoided if he concentrates on particular features of his sheep. The problem of improving carcass quality can of course be left entirely to breeders of mutton and lamb sires for crossing and to breeders of lowland sheep not normally crossed.

38. In the past a great deal has been done to modify conformation, and thereby the shape of the carcass, by selecting breeding stock by eye. It seems doubtful whether much of significance remains to be done in this way unless techniques are devised to reveal what at present only the carcass can show, for instance the amount of fat and the size of muscles. Breeders, however, who feel that something important still remains to be done in respect of, say, leg length and conformation of shoulder or hind quarter, may look forward as before to a response from selecting breeding stock by eye.

39. It is to be hoped that objective standards of carcass excellence will be developed in the near future. When the standards exist it should be possible to assess the merit of rams, in relation to carcass quality, by reference to the carcasses of their progeny or of their half brothers or half sisters. It seems beyond doubt that such assessment will have to be based on appropriate written records; but at present the Committee can give no guidance as to the form that such records will have to take.

Hardiness

40. Although hardiness is often mentioned as an important quality, it is so poorly defined as to make it difficult to discuss. It seems that hardiness is a comprehensive term covering ability to live and reproduce satisfactorily under the conditions offered. Whatever the conditions, natural selection will persistently kill off those that are too soft for them, and will moreover do this more efficiently than man can. Research is being undertaken into several aspects of this problem and may well yield valuable information. In the meantime we have adopted the view that those sheep which perform well in a given set of conditions are hardy enough.

Fleece weight and quality

41. The repeatability and heritability of fleece weight and of some aspects of fleece quality, for example of crimp and staple length, are believed to be relatively high. It is also known to be possible to influence, by breeding, the distribution of the fleece over the sheep's body and the shedding of wool from parts of the body. If a flockmaster wishes to change average fleece weights in his flock the recording of this character in females is probably essential; and such recording is likely to be helpful if he wishes to change fleece qualities or distribution. Little is known about possible inter-connections between fleece weight and other characters such as milk production and viability of rams.

CONCLUSIONS

42. We have no doubt that retention and breeding from sheep of better than average performance in relation to a particular character will tend to enhance that character in the flock and in the offspring. Progress will be fastest with characters of high repeatability and heritability, like fleece weight. But the repeatability and heritability of some characters which we think to be of great economic importance—particularly prolificacy, milking capacity, growth rate of young lambs, and weaning weight—appear to be relatively low. Some other important attributes, particularly carcass quality, are complicated and no general specification of breeding objectives is possible. For characters of low repeatability and heritability, the rate of any genetic improvement in a flock is bound to be slow. Such characters respond rapidly and profitably to better management and, consequently, there is little point in attempting to breed for them until management is as good as it economically can be. We recognize that breeds differ in these characters and that prospects of improvement by breeding may be much better when one breed is being graded up to another; or in the process of

breed formation from a crossbred foundation. We are also satisfied that, if culling or selection is attempted for two or more characters simultaneously, the rate of progress towards desired objectives with any one of these characters will inevitably be reduced; and we have concluded that if the productivity of a flock is raised, management problems will be intensified.

Chapter 4: Present Practice in Regard to Sheep Recording and the Scope for Development

RECORDING IN GREAT BRITAIN

43. It is well known that ewe records have been kept at research institutes for various purposes for many years. It is also well known that for many years individual breeders have recorded the performance of their ewes, have used the records as a basis for culling and in some cases for evaluating rams, and have been satisfied that worthwhile improvements in flock productivity have been achieved. But so far as we have been able to discover, there are only three schemes in this country designed to foster the use of standardized records in commercial flocks. These are the Oxford Stud Sheep Health and Improvement Scheme; a scheme sponsored by the National Sheep Breeders' Association and the Farmer and Stock-Breeder; and a scheme sponsored in the Eastern counties by the Ministry of Agriculture, Fisheries and Food.

44. The Oxford Stud Sheep Health and Improvement Scheme was started in 1952, and is based on the Nuffield Institute for Medical Research at Oxford. The original objective was to improve flock productivity and health through a system of records which would in time provide a basis for selection of breeding stock by reference to lifetime performance. Initially, attention was concentrated on health; the recording of live weight gain commenced in 1957; and the appraisal of wool, in collaboration with the British Wool Marketing Board, began in 1958. There are now some 60 flocks in the scheme, representing ten breeds and with a total of some 9,000 sheep. We have considered such information as has been made available to us about results that have been achieved in flocks participating in this scheme. We have noted that since the scheme started there has been no improvement, on average, in the ratio of lambs reared to ewes put to tup; but we understand that many of the participants have not been primarily concerned to improve this character, anyway. We have had no evidence that the scheme in its present form has led to genetic improvement in the flocks concerned.

45. The N.S.B.A. and Farmer and Stock-Breeder Scheme started in the autumn of 1958. Some 300 flock owners are taking part. A sheet for each ewe provides for recording the number, sex, and date of birth of her lambs, the lambs' weights at birth and at twelve weeks and at an intermediate stage at the discretion of the flockmaster, the weight and quality of the ewe's fleece, and remarks about health, treatment and other unspecified information. It is too early to attempt an assessment of the value of this scheme since only one year's records are in existence.

46. The Eastern Region Scheme was designed to try to find the simplest and most accurate way to record details of the life history of ewes in order to evaluate the standard of management in the flock and the individual worth of each ewe. It was started in the autumn of 1958 with fourteen flocks representing five different breeds and with a total of about 1,700 ewes. Again it is too early to reach conclusions about the scheme.

RECORDING OVERSEAS

47. We have studied reports of overseas work on sheep recording and progeny testing that were supplied to us by the Commonwealth Bureau of Animal Breeding and Genetics, the Agricultural Attachés, and overseas research workers and institutions. In addition the Chairman visited the University of Wisconsin to obtain further information about the scheme

of sheep recording organized by the University and also met some of the farmers participating in the scheme.

48. A brief description of the Wisconsin Scheme is included as Appendix 3 together with a summary of results for the years 1950 to 1959. We realise that there is need for caution in drawing conclusions from a summary such as this. Complications are that some new flocks came into the Scheme during the period while others dropped out; and no account can be taken of changes in management which might have taken place independently of any use made of the records by participating farmers. Nevertheless, the summary demonstrates improvements in average prolificacy and average lamb weights; and it is reasonable to infer that part at least of these improvements is a consequence of the use of records.

49. We were very interested in the information made available to us about other overseas work on recording and progeny testing and are most grateful to those who supplied it to us. But we have not found it to provide specific guidance about desirable developments in this country.

THE POTENTIAL VALUE AND USES OF RECORDS

50. We have thus found little published evidence of the value of recording. It has, moreover, to be recognized that it must always be difficult to evaluate the merits of recording because of the inevitable lack of comparable data from unrecorded flocks. We accept, however, that individual breeders who have recorded their flocks have been able to increase average prolificacy and productivity by breeding successively only from females which have been bred from parents of above-average fertility, and which have themselves shown above-average fertility or productivity in their first two pregnancies. Evidence is lacking on how far this has been the result of environmental factors, particularly standards of management and control of disease; but it seems likely that these have been the main cause and that selection for heritable factors has played a smaller part. Evidence is also lacking on how prolificacy, in particular, can continue to be increased in practice by this method.

51. We are satisfied that a wider use of simple records would lead to improvements in management. Deficiencies would be brought forcibly to the flockmaster's attention which, without written records, might be overlooked. Records can, for example, be used when searching for causes of trouble in a flock by pinpointing numbers of barren ewes, numbers of still births, low birth weights and so on.

52. Records of individual sheep can also be used for deciding which to cull with a view to increasing flock performance. This is easy to practise and to justify in general terms. The difficulty comes in deciding what standards to set for each character and each age group. Until more facts are available, each man will have to decide these things for himself and it will not be easy to achieve maximum efficiency without the facts. It would be necessary to know, for instance, how accurately performance to date will predict future performance, character by character; how early in life culling should occur; how it should be distributed over the various ages, and on what standards. It is possible to overcull and exchange the substance of a high proportion of mature animals for the shadow of higher performance. No answer can be given to either a particular or a general question about the most effective rate of culling at any age. It could be worked out in theory only by making assumptions about:

a. the frequency of gross defects that force culling;
b. the predictive value of a record of performance for future performance;
c. the range of variation in each character in a flock;
d. the economic value of improvement by culling, character by character;
e. the correlations between characters.

53. Individual records can also be used for the selection of breeding stock. As with culling, it is not possible to do more than give general guidance as to this form of use. Every breeder likes to choose his best sheep as parents of the next generation. Definition of the word "best" must be left to him. This much can be said, some characters, such as fleece weight and growth rate after weaning, will yield to selection pressure more than others, such

as milk production and prolificacy. Further, progress will be faster when attention is concentrated on one character than when it is concentrated on two or more.

54. A final and important use of records within a flock is to facilitate the comparison of rams and hence the selection of the best for future breeding.

55. Records also have a limited value as a basis of comparison between flocks. They can, for example, be used to compare average fecundity, weights, etc., between similar flocks on similar land and thus to indicate adequacies of pre-natal feeding and of the growth of rate lambs in relation to stocking density. The difficulty is to determine that the essential similarities of flocks and land really obtain.

56. It does not follow that recording is always worth while; for many flockmasters in fact it probably is not. Recording takes time and it takes money for record books and for equipment such as eartags, weighing machines and so on. Some breeders will regard the outlay as justified merely by the greater interest afforded to their occupations. It is difficult to assess or to forecast the effect of an improvement in management or a change in emphasis in breeding policy. But ram breeders who are intent on securing improvements to economic characters are unlikely to do so without recording ewes and their lambs; and those breeders who buy but do not sell rams can use records to improve the performance of their ewe flock through judicious culling. Many breeders still have a strong faith in the visual appraisal of the breeding value of a sheep; but whenever it is possible to replace visual judgement by objective measuring or weighing, accuracy is greatly improved, and the benefit of being accurate lies in better prediction of future performance.

CONCLUSIONS

57. We have concluded that ewe recording in commercial flocks ought to be extended. We see its main value as an aid to flock management and health control; but it should also be useful, particularly in relation to characters of high repeatability and heritability, as a guide to culling and to the selection of ewes for future breeding. We think that such records will be useful mainly within individual flocks; that the ways in which records can best be used in any flock must be determined by the flockmaster's individual problems and objectives; and that the use of records as a basis for comparison between flocks is limited. We are also confident that the extension of recording and expert analysis of the results from individual flocks will in time enable more precise recommendations to be formulated about the uses of recorded information. The extension of recording would have the further effect of directing the attention of flockmasters to characters of economic importance, with the consequence that breeders from whom they purchase stock would give prominence to these characters in their breeding objectives. Finally, records of ewes and lambs are indispensable to those who wish to attempt constructive ram breeding.

Chapter 5: The Form of Ewe Records, and Practical Aspects of Recording

GENERAL CONSIDERATIONS

58. We have appreciated that a case can be made out, on general farm management grounds, for keeping records of flocks rather than records of individual sheep. Flock records can show, for example, year by year changes in total and average weights of lambs sold, and total and average weights of wool produced by a known number of ewes. We think, however, that if recording is to provide an effective basis for increasing the productivity of a flock then records of individual sheep are essential.

59. We have stated our view that a flockmaster should concentrate recording on the character, or as small as possible a number of characters, that he wishes to foster. In paragraphs 8–14 we have stated the characters which we suggest to be of greatest economic importance in different categories of flock. It follows that we do not envisage that the same kind of information should be recorded by all flockmasters who adopt recording, and indeed we think that it would merely cause them unnecessary work and perhaps confusion to record information which was of relatively little importance to them. Thus we repeat that the individual flockmaster must first decide the relative importance to him of the various characters in his flock; and that only after this can decisions be taken about the kind of recorded information likely to be of value to him.

60. In our opinion, the amount of detail in forms of record should match the use that is likely to be made of them. A fairly simple form will suffice if the records are to be used primarily as an aid to management while a more complicated form becomes inevitable if the records are to be used as the basis of constructive breeding.

A SIMPLE FORM OF EWE RECORD

61. At Appendix 4 is a form of record which should meet the needs of those who are using records mainly as an aid to management. This has been drafted to specify the basic information which we think most, if not all, will need, while at the same time making provision for the flockmaster to record additional information which he regards as important. For many people it will be sufficient to know the weaning weights of their lambs, and to regard these as an indication of the growth rates of the lambs and hence of the milking capacity of their dams. Those who are particularly interested in, for example, using records of early growth rate of lambs to check the pre-natal feeding of their ewes, may like to record weights at birth and six or eight weeks also. In general, flockmasters using this form will probably not wish to bother with correction factors (see paragraphs 34–35) in order to adjust weaning weights for age and sex of lambs or litter size.

A MORE COMPREHENSIVE FORM OF EWE RECORD FOR RAM BREEDERS

62. The specimen form at Appendix 5 is essentially of the same kind as the simple form. Again we have indicated information which we think will have to be recorded and have suggested spaces for use at the discretion of the breeder who wishes to record additional information. We think that specific provision must be made for weights at ages other than weaning; and that the breeder will be concerned with the performance of individual ewes to a greater extent than the man who uses records for management purposes. We think too that constructive breeders will have to take some account of correction factors for lamb weights to which we referred in paragraphs 34–35 where we explained that it is impossible to specify what these should be in all flocks. For purpose of illustration, we have included in the specimen form the correction factors detailed in paragraph 34, while recognizing that these are unlikely to be applicable to all flocks. Also, unless all lambs are weaned at the same age, weaning weights will have to be corrected for age for purposes of comparison between ewes; for practical purposes linear rates of increase can be assumed for say two weeks each side of a normal weaning age of twelve weeks, and this correction for age can conveniently be included in a simple ewe index as indicated in the form.

63. It has been represented by Mr. H. B. Parry that detailed records of the health of stud flocks should be given much greater prominence. The other members of the Committee do not underrate the contribution of health to productivity or doubt that records of the health history of a flock may be extremely valuable, particularly to the flockmaster's veterinary adviser. There is provision in the specimen record forms (Appendix 4 and Appendix 5) for health matters to be recorded if the flockmaster so wishes. The majority of the Committee does not consider, however, that specific recommendations can be made at present for the institution of supervised health recording for all stud flocks. Mr. Parry dissents from this

view and has accordingly prepared the separate report on this subject in chapter 9.

64. We have noted that in some recording schemes, particularly those operated in the U.S.A., relatively complicated indexes have been compiled to measure the merit of ewes for several attributes simultaneously. The construction of such indexes requires assumptions to be made both about the heritability of the characters included and about their economic importance; and we have felt that there is insufficient information of general application to British sheep to justify our advocating the use of such indexes at present.

CHECKING RECORDS

65. When records have to be compiled under farm conditions, mistakes can easily be made in the entries. This may not matter a great deal if the flockmaster is concerned only with average results, but can be seriously misleading if he is interested in the performance of individual animals. It has been found by those who are already recording ewes in ram breeding flocks that it is worth while to keep a list, apart from the main records, to specify the ewes in particular sections of a flock. On this list the ewes put to each ram, changes of ram, and identities of lambs born, can be noted prior to transcription to the permanent records. Such lists can be invaluable in resolving apparent discrepancies in the records.

IDENTIFICATION OF EWES AND LAMBS

66. Some permanent method of identifying ewes is essential if even the simplest recording is attempted. Methods at present in use are ear notching, ear punching, horn branding, tattooing the inside of the ear with numbers or letters, and fitting numbered plastic or metal tags in the ear. Practical experience has shown that with any one of these methods identification can be lost through accident of one kind or another and that it is a wise precaution to use two methods simultaneously or to duplicate marking where this is possible, e.g., by putting a tag in each ear.

67. With ear notching or punching the position of the notch or hole indicates a number in accordance with some pre-arranged code. This method is cheap and simple, but a drawback is that the occasional inevitable mistake in position cannot be rectified. Other drawbacks are that the ear, particularly of a young sheep, can be seriously mutilated, and a part of the ear may subsequently be torn off; and that any holes in the centre of the right ear, or serious mutilation of that ear, may lead to the refusal of certification under the Ministry's fatstock guarantee arrangements. If notching or punching is adopted, it is important that the instrument used should cut clearly and precisely.

68. To tattoo inside the ears is also cheap and simple where this is practicable, but tattoo marks can become indistinct as time goes by, and it may be necessary to clean the ears before the marks can be read at all.

69. Plastic or metal ear-tags appear to be gaining in popularity and to offer considerable advantages. They remain easy to read, and different colours of the plastic variety can be used for sheep of different ages or of different sections of a flock. It is an advantage to tag lambs born dead to avoid subsequent confusion through counting them more than once. A few tags may be lost from the ears, and the ideal might well be a tag in each ear or a tag in one ear and a tattoo mark in the other.

Chapter 6: Ram Breeding and Testing

PRESENT POSITION

70. For a very long time, probably for centuries, breeders of sheep must have taken account of the quality of a ram's offspring when considering his merit for future breeding. In doing this flockmasters and their shepherds have relied in the main on inspection of the offspring and on their memories rather than on any formal record. We do not doubt that

this process has contributed to the changes that have been made over the years in the conformation of British sheep. Obvious limitations are that it can be useful only for the assessment of attributes that can be readily judged by eye; that its usefulness is inevitably related to the heritabilities of these attributes; and that the general intensification of agriculture probably leaves flockmasters less opportunity today than formerly for close observation of individual animals.

71. Progeny testing, in the commonly accepted sense of evaluating parent animals by reference to the recorded performance of their offspring, has been widely practised by research organizations in this country and abroad. It is indeed through this work that the heritabilities of various attributes of sheep have been established.

72. We have not discovered that, outside research organizations, many breeders are using written records to assist them in evaluating their rams through progeny testing or in any other way. To some extent this is undoubtedly happening in the flocks that are recorded under the schemes mentioned in paragraph 43; and we have been assured that some flockmasters are certainly convinced of the value to them of records.

METHODS OF SELECTION

73. A great deal of what we said in relation to ewe recording is also directly relevant to ram evaluation. In the first place, the economically important attributes we listed in paragraphs 8–14 are inherited from both the male and the female parents; and secondly, for attributes like prolificacy which are exhibited only by the female, a ram can be evaluated only by reference to the performance of his female relatives. Thus records of the performance of ewes and of their lambs provide much of the information needed to evaluate rams as well as ewes.

74. In our view it is impossible to comment usefully on the possibilities and limitations of any method of breeding without some examination of the methods of selection that are available and their relevance to the likely objectives of breeders.

Individual and family selection

75. In chapter 3 we discussed the repeatabilities and heritabilities of the attributes which we consider to be of most economic importance in the various categories of flock; and noted that on present evidence the heritabilities and repeatabilities of some appeared to be high and of some relatively low. When the heritability of a character is high, the performance of the individual animal in relation to that character gives a fairly reliable indication of the likely performance of its progeny. The choice of parents for the next generation by reference to their own performance is generally known as individual selection. When heritability is low, individual performance is a much less reliable guide, and it is necessary to take account also, and often preponderantly, of information about the animal's relatives. The latter is the basis of family selection. Selection based on the performance of progeny is one form of this; but the family may be the animal itself together with its full brothers and sisters or half brothers and sisters (generally known as sibs or half sibs), the progeny of the animal, or a combination of these. Progeny testing gives the most accurate guide to breeding worth in relation to any character, but as we explain later there may be practical reasons for employing less accurate methods of selection.

76. The family, in the case of a progeny test, is here regarded as the produce of a particular sire. For a lamb the family can be the group of half-sibs of which he is a member or the group of half-sibs of which his dam is a member; the former would be of interest if the purpose were to retain, for breeding, ram lambs from the best families as judged by lamb performance; and the latter if the purpose were to identify the best group of ewes and to keep some of their sons. It is perhaps unnecessary to stress that comparisons between families, in order to identify genetic differences, are more reliable when the families have been subjected to the same environmental conditions throughout the period relevant to the comparison; and when the sizes of the families compared are large enough to minimize chance differences.

77. When family selection is used it has in practice to be combined with individual selection because only a few males can be tested in the flock in which they were born. As a rule, there is a two-stage process of selection; numbers may be initially reduced by rejecting all those animals whose own performance is below a certain level and then a further reduction is achieved by preferring members (or parents) of some families to members (or parents) of other families; or the reductions are attained in the reverse order. Which stage comes first will depend on which characters the breeder thinks most important, those of the lambs or those of their parents.

78. Even though individual performance is a less reliable guide to breeding merit than progeny testing, it may be better in practice to make limited progress quickly by individual selection, than to wait for the results of family selection which would facilitate greater accuracy. In this connection, the sib test may provide some breeders with a reasonable compromise between individual selection and selection based on a progeny test; the sib test avoids the delay of a generation which the progeny test involves. This conflict between rate of progress and accuracy, and the different rates of progress that are possible with different characters, make it important that the individual breeder should consider carefully the characters which it would best pay him to improve. Although, for example, he might ultimately gain most by improving a character like prolificacy through selection based on progeny testing, in his particular circumstances it might be more attractive to concentrate on much faster improvement of fleece qualities through individual selection.

Pedigree selection

79. What we have said above points to the uses and limitations of selection based on the pedigree system. It has to be borne in mind that for sheep, as for most farm animals, registration in a flock book is selective because a breeder normally registers only those animals which conform to breed type. Discrimination by reference to breed type inevitably precludes to some degree discrimination by reference to productive characters that are not associated with breed type. This has two consequences. Firstly, in itself the registration of an animal gives little indication of the extent to which it possesses or is likely to transmit those characters. Secondly, the members of the animal's family that are registered will not include those inferior in breed type, and so the registered family will be incomplete; and conclusions about the animal's breeding merit in relation to those characters, that are based on the performance of the registered members of the family, are therefore liable to be misleading.

80. Thus the choice of a pedigree animal for breeding is likely to be most advantageous in relation to characters that are both highly heritable, so being appropriate to individual selection, and associated with breed type. Unfortunately these do not appear to include some of those characters which we have stated to be of prime economic importance. Furthermore, unless pedigree breeders record the performance of their sheep, pedigrees can but rarely be supplemented by details of the performance of the animals registered. Pedigree without such details can convey an impression of superiority which is in no way related to economic worth.

81. We also think it important to recognize that remote ancestors contribute very little to the genetic make-up of an animal and so to its performance or breeding merit. We realize that, traditionally, importance has been attached to eminent ancestors in an animal's pedigree, but we are extremely doubtful whether much weight should be placed on any more remote than its parents. What must be beyond doubt is that taking account of remoter ancestors inevitably distracts attention from the more relevant information obtainable from the animal itself, its parents, its full or half brothers or sisters or its own progeny; and so reduces improvement in any direction that the breeder is seeking.

THE SCOPE FOR PROGENY TESTING

82. We realize that the present structure of the pedigree breeding industry may restrict the scope for progeny testing, both because of the comparatively small sizes of pedigree flocks and of the comparatively short durations of many of them. A recent survey, by Dr.

G. Wiener of the Animal Breeding Research Organisation, of 2,649 registered pedigree flocks in fourteen breeds showed that:

a. nearly 65 per cent of all the flocks contained fewer than 100 ewes; only about 15 per cent of the flocks contained more than 200 ewes; and in some breeds there was no flock as large as this;
b. the average age of the flocks still in existence varied from 8 to 22 years. Excluding the Clun Forest, Ryeland and Shropshire breeds, for which no figures were available, 61 per cent of flocks were less than 10 years old and only 18 per cent more than 20 years old;
c. over 35 per cent had only one ram in use, about 30 per cent had two and 9 per cent had more than five;
d. some 2·3 per cent of flocks provided the sires of 61 per cent of registered ram lambs.

83. The figures in the preceding paragraph suggest that among pedigree flocks included in the survey, only a minority were large enough, and appeared to endure long enough, to be able to take advantage of methods of breeding based on progeny testing. It will be noted that in about a third of the flocks only one ram was in use, and in another third only two. If there is only one ram there can be no comparison of ram progeny groups, and a breeder using only two rams in a season is seriously limited in the value he can derive from the comparison particularly if the rams are not used on ewes of the same ages. Further if that breeder prefers one of the two rams, he will be confronted with the problem of inbreeding if he wishes to use one of its sons in due course. Indeed, even if he keeps a son from each, he will meet the same problem a generation later on. Certainly the effects of inbreeding on sheep are but poorly known but what evidence there is strongly suggests that the very traits the improvement of which might lead a breeder to family selection, namely, fertility and viability, would be the ones to suffer most from inbreeding.

84. We appreciate that a registered flock may not contain all the sheep on a farm so that the owners of comparatively small pedigree flocks may nevertheless be able to test novice rams on a sufficiently large number of unregistered ewes and bring only proven rams into the registered part of the flock. We accept that it is not necessary to test rams or compare families in terms of purebred animals; in fact, for evaluating rams of breeds which are commonly used for cross-breeding, there may be advantages in evaluating the rams in terms of their cross-bred offspring. We do not know how far these extended testing facilities might be available to the owners of the smaller pedigree flocks. We can only say that without some such opportunities, or co-operation in testing with other breeders, progeny testing cannot help them much.

85. The figures in paragraph 82 also illustrate the dependence of pedigree sheep breeders on the comparatively few flocks in each breed that provide the bulk of their rams. It follows that only the genetic changes that can be brought about in these flocks can be of much importance, because they are the only genetic changes with much chance of spreading throughout a breed. It is not for us to suggest whether or not such changes are likely in these flocks or whether changes are most likely to be made by breeders outside the pedigree structure. We understand that some flockmasters appear to prefer non-registered to registered rams, presumably because they believe that there are commercial advantages to be gained by doing so.

PROBLEMS FACING THE CONSTRUCTIVE BREEDER

86. We recognize that the majority of sheep breeders will continue to buy their rams. Ewe recording would help them in the ways outlined in paragraphs 50–57 and they could use family testing to assist them in selecting ewes for future breeding. Progeny testing to evaluate rams is likely to be of value to them only if they buy sufficient rams each year, and can test them on sufficient ewes, to make worthwhile comparisons of the breeding merit of the rams. If they can do this they can then use the best ram for the remainder of his useful life and, if they have confidence in the breeding methods employed by the ram's breeder, buy another from him when a replacement is required.

87. We have already emphasized that it is extremely difficult to lay down any universal specification of sheep breeding objectives or of the best techniques to achieve them. What

does concern us, however, is that very few breeders, so far as we know, are either concerning themselves to define economically desirable objectives or taking advantage of modern methods to attain them. We feel that after making due allowance for the complexities of sheep husbandry, sheep breeding is backward in these respects by comparison with the breeding of pigs, poultry and dairy cattle.

88. We therefore make no apology for defining a constructive breeder as one who is determined to remedy this state of affairs. He has to decide:

a. what his objective is to be;
b. what are the most effective ways of reaching it; and
c. how best to match his physical resources, such as flock size and facilities for mating and for recording, with the project.

89. We have listed in paragraphs 8–14 the characters that we regard as of most importance in the various categories of flock. These therefore constitute our guidance on the breeder's choice of his objective.

90. The most effective ways of breeding towards an ideal are now much better understood than formerly. But detailed genetic information about British breeds of sheep is scanty and consequently it is quite impossible to lay down precise rules for the selection of breeding stock. Much, however, that is generally applicable is known and may be summarized in the following simple rules:–

a. simplify the objective;
b. shorten as far as possible the time required to test an animal;
c. use individual selection for characters of moderate to high heritability and family selection for those of low heritability.

91. The adaptation of physical resources to a breeding project may be complicated. The recording of ewes and lambs is the most important change that many breeders would have to face and has been discussed already. Variation due to environment can be reduced, for example, by making comparisons only between sheep of similar ages, rotating mating groups round the fields in use, and by devising correction factors as suggested in paragraph 35. Desirable numbers for a valid test depend on the heritability and importance of the individual characters being considered; and the choice will probably have to be made between testing a small number of rams comparatively accurately or testing a larger number less accurately.

APPLICATION OF BREEDING TECHNIQUES

92. Having stressed the need for the individual breeder to consider his own breeding objectives and problems it may be helpful if we indicate the breeding techniques which we think must normally be used to secure worthwhile improvements in the various categories of flock described in paragraph 7.

93. *Hill flocks.* We have said that the important characters are hardiness, the ability to rear a 100 per cent lamb crop, and satisfactory quality and weight of fleece. Individual performance is appropriate for the assessment of fleece attributes and perhaps for hardiness (but see paragraph 40). Individual performance is of limited value for the assessment of prolificacy and this can only be investigated effectively through a progeny or sib test, preferably the former.

94. *Lowland flocks producing the sires of cross-bred ewes.* We think the important characters here, in descending order of importance, are prolificacy, milking capacity and growth rate. Individual performance gives a satisfactory guide to the latter, while for prolificacy and milking capacity individual performance must if possible be supplemented by progeny or sib testing. A specimen breeding scheme is in Appendix 6.

95. *Lowland flocks producing their own replacements, females for sale and fat lambs.* The important characters here, again in descending order of importance, are prolificacy, milking capacity, growth rate and carcass quality. For the first three, considerations are as in paragraph 94. We have mentioned in paragraphs 37–39 the difficulty of assessing carcass quality

and hence of breeding for its improvement. If improvement is attempted this can only be through progeny or sib testing. A specimen breeding scheme is in Appendix 7.

96. *Lowland flocks producing fat lamb sires.* The essential characters here are growth rate and carcass quality. The former can be improved by individual selection. The improvement of carcass quality through breeding must again be based on progeny or sib testing. A specimen breeding scheme is in Appendix 8.

97. *Lowland flocks producing mutton sires.* The important characters here, again in descending order, are carcass quality, growth rate, and weight and quality of fleece. We have discussed carcass quality in paragraphs 95 and 96. Again, growth rate and fleece attributes can be improved by individual selection.

98. *Lowland flocks being developed for above-average lambing frequency.* We have listed the important characters here as, firstly, above-average lambing frequency, followed by reasonable prolificacy and milking capacity. The first may be improved by individual selection while the second and third again require a progeny or sib test for their improvement.

CENTRALIZED TESTING OF RAMS

99. In paragraphs 93–98 we have indicated the breeding techniques that we think are appropriate in various kinds of flock. The adoption of these techniques must remain, with one possible exception, entirely a matter for individual breeders. For characters of low heritability, like prolificacy and milking capacity, the variety of environments in which sheep are kept and the number of progeny required for a reliable test would make impracticable any form of centralized testing.

100. The exception relates to the performance testing of young rams intended as potential fat lamb sires. Flocks producing these rams are of very great significance to the industry and we have noted that growth rate is the most important quality to be contributed by the ram to his offspring. The best available evidence shows, as we have indicated in paragraph 33, that the heritability of growth rate can be relatively high so that the measurement of the weight gained by a young ram over a suitable period after weaning can provide a reasonably accurate guide to the capacity for early growth that he will transmit to his offspring. There is good reason to expect, therefore, that a comparison of growth rates of young rams under uniform environmental conditions would yield valuable information about their relative usefulness as fat lamb sires. We think that it would be wrong to recommend ram performance testing centres without further investigation through a pilot experiment. But the potential value to the industry of such centres is so great that we recommend that suitable investigations should be put in hand as soon as possible at one of the Ministry's experimental farms or elsewhere.

ARTIFICIAL INSEMINATION

101. We realize that if artificial insemination were widely adopted the breeding merit of rams could be evaluated more accurately than is possible with natural service; and that the influence of proven rams could be greatly extended. We understand that there would be no insuperable physiological difficulty about artificial insemination of sheep; but we recognize that there would inevitably be considerable practical difficulties in the organization and use of this breeding technique for sheep in this country, and that the economics of an artificial insemination service might well be much less attractive than for cattle. In reaching our conclusions therefore we have disregarded any likelihood of the widespread use of artificial insemination for British sheep in the near future.

CONCLUSIONS

102. We think that if flockmasters are to improve their sheep in directions which now appear to be economically desirable, many of them will be compelled to base their breeding methods on written records. For a number of the desirable characters, the possible rate of progress in each year will not be great, and only written records will provide a sufficiently accurate basis for reliable selection. Limitation of breeding objectives is essential for progress,

so that one or a very few of the most desirable attributes must be given absolute priority over less important factors.

103. For the economically important attributes which are of low heritability, selection will have to be based on the average performance of groups of sheep, e.g., on the average performance of a group of ewes or a group of lambs by one sire.

104. Even where the breeder is ready to record, we do not think it practicable to prescribe in any general terms the breeding system that each should adopt. What is desirable is that each breeder should become aware of the methods that are most likely to attain his breeding objectives. He will then see what records he needs to keep and how these are to be used. His rewards will be in more profitable sheep in his own flock and more profitable sheep to offer to his customers when they too recognize the value of stock that has been bred for specific economic objectives.

105. We do not think that centralized progeny testing is practicable for sheep. But we recommend that the possibilities of centralized performance testing of potential fat lamb sires should be investigated urgently through a suitable pilot experiment.

Chapter 7: Encouragement and Supervision of Recording and of Breeding Methods Based on Records

THE NEED FOR ORGANIZATION

106. We have concluded that:

a. recording should be extended in commercial flocks, mainly as an aid to management, but also to provide more accurate bases for culling and selection of ewes for future breeding (paragraph 57);
b. recording is essential to constructive ram breeding (paragraph 57);
c. family selection through sib testing or progeny testing is essential to the improvement through breeding of characters that are both economically important and of low heritability (paragraph 103).

107. We have also explained that although these recommendations can be stated in general terms, it is impossible to formulate in such terms a blueprint for each sheep breeder.

108. We have tried to set out the considerations that should facilitate decisions about the records to be kept and the breeding techniques to be used in individual flocks. The subject is complicated and departure from traditional practices will require explanation and personal persuasion. We therefore think that progress with recording and changing emphases in breeding will depend on sustained efforts in publicity and advice.

109. The provision of education and advice is not the sole responsibility of any one organization. Breed societies could help a great deal by redefining the most important characters within their breeds, and what we have said should help them to do so. They could then actively encourage their members to concentrate attention on these. We also feel that further important contributions towards improvement of our sheep could be made by the agricultural advisory services, by educational establishments and by the agricultural press; these can all help to create the demand for improved animals that will provide the necessary incentive for breeders.

110. We have noted that the main value of records is within individual flocks and that caution is needed in attempting to base conclusions on comparisons of the recorded performances of different flocks. We realize, however, that it must be helpful to know how results in a particular flock compare with breed, regional, or national averages if only to prompt investigation into the reason for differences between individual flock results and those averages. We have also noted the scarcity of information about the performance of British sheep which limits the precision of any analysis of the scope for improvements; and which precludes at present the formulation of selection indexes to simplify the application of recorded information. For these reasons, some central compilation and analysis of records is very desirable.

111. Although some flockmasters will doubtless be ready and able to devise and use forms of record appropriate to their flocks and objectives, others will be encouraged to start recording only if the basic forms are made available to them. We also consider that it will be an incentive to many to know that they are taking part in an organized recording movement specially devised to help them and to which they in their turn can contribute information.

112. We have concluded that the development of recording requires some active central organization, ensuring personal contacts with flockmasters and offering them some basic services.

FUNCTIONS OF CENTRAL ORGANIZATION

113. We think that in general terms the functions of the central organization should be:

a. to foster the development of sheep recording;
b. to encourage the development of performance-bred flocks;
c. to recommend methods of progeny testing and performance testing;
d. to formulate selection indexes as soon as this becomes possible;
e. to investigate the possibilities of centralized performance testing of rams.

114. In paragraphs 61–62 we have distinguished between simple ewe recording as an aid to management and more advanced recording for use in ram breeding flocks. The information to be recorded is similar in each; the main difference comes in the interpretation and use of the recorded information.

115. We think that the organization of the simpler kind of recording, which is likely to attract the greatest number of participants and indeed to be of the greatest immediate value to the industry, must embrace:

a. the provision of record forms;
b. advice to flockmasters on the type of recording suited to their breeding objectives;
c. visits to participants;
d. analysis of records.

116. The more advanced kind of recording, and the development of breeding techniques based on this, will, we think, require a closer association between the breeder and his adviser. In addition to the services mentioned in paragraph 115 we think that the central organization should be able:

a. to provide advice on the allocation of ewes to rams;
b. to promote co-operation between flockmasters so that rams can be tested on sufficient numbers of ewes.

117. We see no reason why these services should be provided free of charge by the central organization. Flockmasters participating in the Farmer and Stock-Breeder and N.S.B.A. Scheme and the Oxford Scheme pay for the record books supplied to them. Participating farmers also contribute towards the cost of milk recording and pig recording schemes. Experience with those schemes has shown, however, that the organizing authority is unlikely to recover the whole of its expenditure from fees charged to those taking part. Too high a fee will discourage farmers from recording at all, or will discourage them from taking part in an organized scheme and so deprive the central authority and the industry of the benefit of their experience. We recommend therefore that the participant should pay for record forms and for essential equipment such as marking instruments, identification tags and weighing machines; and that in return for the data supplied to the central organization by flockmasters, analysis of the data for their benefit and any publication of results that is decided upon should be free of charge. Whether the advice and other assistance offered to the flockmaster in connection with his recording should also be free of charge will depend on the constitution of the central organization, and on whether it is intended to give the farmer any promise of individual services such as detailed analysis of his own flock records. Advice on other aspects of management and breeding problems is afforded free of charge through the agricultural advisory service in Great Britain, but of course the farmer is given no right to demand particular attention.

118. We consider it important to ensure that the identities of the flocks to which particular results relate should not be disclosed in published information. There are two reasons for this. Firstly, if recording became unduly competitive, we think that the accuracy of some records would suffer. Secondly, if records were published against the name of the flockmaster by any independent authority, the impression would be created that the authority guaranteed their accuracy. We do not believe that any central authority would be able to do this, since there is no practicable way of checking such fundamental facts as the identities of rams to which ewes have been mated and the parentage of the lambs credited to each ewe.

119. It follows from what we have said in the preceding paragraph that we think it would be extremely difficult to administer any scheme for the accreditation of the performance of individual flocks.

120. We have considered whether any financial incentive is necessary to stimulate change in breeding methods. We recognize that any change in breeding methods might lead in the short term to lower rewards for some breeders; but we have no reason to think that this section of the sheep industry is or will be in need of special financial help, or that such help would be popular with other sections of the industry. The acceptance of recording by commercial farmers will focus their attention on productive traits and will lead them to demand stock that has been bred to excel in these. The constructive breeder will, we think, realize that there is no time to be lost in preparing to satisfy this demand and to be ready to provide supporting records when these are needed.

FORM OF CENTRAL ORGANIZATION

121. The central organization will have to employ staff of adequate calibre to advise flockmasters about the style and interpretation of records appropriate to their flocks and breeding objectives. It will need to be of sufficient status and permanence to attract staff of the right kind; and it will need money to pay them and to meet any other costs not covered by fees charged.

122. The response to the Farmer and Stock-Breeder and N.S.B.A. Scheme suggests that interest in recording will not be confined to particular parts of the country, so that a service covering the whole of Great Britain will have to be envisaged. It has to be expected also that the staff advising on recording will have peak periods of activity at lambing time in the spring and when records are being used in the autumn to help in deciding mating programmes. The number of staff required for this peak activity will be more than sufficient during the rest of the year. On the other hand part-time employment is unlikely to attract staff of the right calibre or ensure the continuity in advisers that is important. We therefore think that the staff helping with the sheep recording in the field should ideally be people who can fit this in with other livestock duties throughout the country. These considerations point inevitably towards assistance by the existing Livestock Husbandry Advisory Officers of the National Agricultural Advisory Service in England and Wales and the officials who undertake similar duties in Scotland.

123. It has also to be recognized that, apart from the British Wool Marketing Board (whose functions relate only to wool), there is no organization in the sheep industry comparable with the Milk Marketing Board or the Pig Industry Development Authority which have statutory powers to assist in developments for the benefit of the cattle and pig industries, and statutory authority to raise money to pay for them. Without some similar organization for the sheep industry, we think that the Agricultural Departments will have to assume direct responsibility.

124. We regard it as vital that the central organization should comprise or be advised by representatives of all the interests that would be concerned with sheep recording and breeding methods. We suggest that these should include the Agricultural Departments, the Agricultural Research Council, the British Wool Marketing Board, the National Farmers' Union and the National Sheep Breeders' Association.

Chapter 8: Summary of Conclusions

125. An essential preliminary to the consideration of sheep breeding techniques and the potential value of recording is an appreciation of the problems they may be used to solve. We begin our report therefore with a classification of the various kinds of flocks to be found in Great Britain with a description of their functions and attributes (paragraphs 7–13).

126. We have concluded that in lowland flocks the characters of prime economic importance are prolificacy, milking capacity, growth rate and carcass quality, together with fleece weight and quality in some flocks; and that in hill flocks the most important are hardiness, fleece weight and quality and prolificacy (paragraph 14).

127. Consideration of the genetic and practical aspects of these characters in Chapter 3 leads to conclusions about the possibilities of improving them through breeding and management respectively. It is emphasized that limitation of objectives in a flock is essential to progress towards their attainment (paragraph 42).

128. We give the results of our examination of present sheep recording practices at home and overseas in paragraphs 43–49. These show that published information about schemes at present operating in this country and about the Wisconsin scheme in which we were particularly interested sheds little light on the value of recording. It has to be recognized that this will be difficult to ascertain at any time owing to the inevitable lack of comparable data from unrecorded flocks.

129. We are nevertheless satisfied that individual sheep recording can benefit the industry both in commercial and stud flocks. Its value would probably be most widespread as an aid to management and health control. In the ordinary commercial flocks it helps in the identification of unproductive ewes at an early age, and by making culling more accurate; it also forms a basis for selection in any programme for the improvement of highly heritable characteristics. In stud flocks records are, we think, essential to constructive ram breeding. Records are, however, of limited use for comparisons between different flocks (paragraphs 50–57).

130. In paragraphs 58–62 we have discussed the types and forms of ewe recording most likely to be of practical use and have given in Appendices 4 and 5 specimens of the forms of record we think likely to be useful. We have also noted in paragraphs 65–69 some of the practical points to be watched and have recommended methods of identifying lambs and older sheep.

131. Although our terms of reference dealt only with progeny testing among the various breeding techniques that can be employed, we felt that to make our report comprehensive we should mention other techniques. This we have done in paragraphs 73–81.

132. We conclude that progeny testing or some other form of family selection must be adopted if the more weakly heritable economic characters of sheep are to be improved. We emphasize that it is impossible to formulate any general prescription of breeding objectives to suit the individual flockmaster and therefore of the best breeding methods for him to adopt. We do, however, indicate the considerations that should guide his choice, stressing the need for limitation of breeding objectives and specifying the techniques that appear to us best for improving the characters that we think should be important in the various kinds of flocks (paragraph 92–98). Specimen breeding schemes that have been designed to achieve specific and not general objectives are described in Appendices 6 to 8.

133. We have been impressed by the small number of stud flocks which actually influence gene distribution within any one breed. We believe that these flocks can make a serious contribution to further improvement of important economic attributes only if breeding systems based on individual ewe recording are adopted, and if those attributes are given absolute priority over less important ones in breeding objectives. Where higher lamb production is a prime objective an appropriate form of progeny testing or other system of family selection will be necessary (paragraphs 102–103).

134. In our opinion the wide variety of functions of sheep in Great Britain and the large number of animals involved make it impracticable—with one exception—to make provision at least for the time being of centralized testing facilities for the sheep industry. The exception is the comparison of fat lamb sires. We think it likely that performance testing stations for ram lambs from suitable breeds would be of great value to the industry and we urge that preliminary trials should be started (paragraphs 99–100).

135. We have said that:

a. recording should be encouraged in commercial flocks, mainly as an aid to management, but also to provide more accurate bases for culling and selection of ewes for future breeding (paragraph 57);
b. recording is essential to constructive ram breeding (paragraph 57);
c. family selection through sib testing or progeny testing is essential to the improvement through breeding of characters that are both economically important and of low heritability (paragraph 103).

We are of the opinion however that progress in achieving these aims will depend on sustained efforts in publicity and advice (paragraph 108). We also consider that some central compilation and analysis of records is desirable (paragraph 110). For these reasons we have concluded that the development of recording requires an active central organization, the functions of which we have outlined in paragraphs 113–116. We have also indicated how Breed Societies and others could help (paragraph 109).

136. We see no reason why the services of the central organization should be provided free of charge nor do we think any financial incentive is either necessary or desirable to stimulate interest in recording. We therefore recommend that participants should pay for forms and equipment, although we suggest that the analysis of data sent in by flockmasters and the cost of publishing results (if decided upon) should not be a charge on participants (paragraph 117).

137. We do not contemplate that an organization of the kind we envisage would be in a position to verify the accuracy of all records, and for that and other reasons the identities of individual flocks should not be disclosed in information it published. This leads to the conclusion that it would be difficult for the organization to administer any scheme of accreditation of the performance of individual flocks (paragraphs 118–119).

138. We make no specific recommendation as to the form the central organization should take nor the source from which it should acquire the necessary funds. We do suggest however that assistance in the field could appropriately be afforded by the agricultural advisory services in Great Britain and that in the absence of an organization for the sheep industry comparable, for example, to the Pig Industry Development Authority, the Agricultural Departments should assume executive responsibility (paragraphs 121–123). It would be important that the central organization should be composed of or advised by representatives of all interests concerned (paragraph 124).

Chapter 9: Minority Report on the Importance of Health and its Recording

by H. B. Parry

139. I regret that the Committee have been unable to recommend the inclusion of health recording in stud flocks. In my judgement this is a matter of such importance that it must be brought to notice.

140. The principal reason for recording is to increase the total productivity and profitability of the flock. The potential annual product of many flocks is known to be reduced by 12–15 per cent by disease and ill-health, and in isolated instances by 25 per cent.

141. Experience in the Oxford Stud Sheep Scheme and elsewhere is that this loss is

caused in most flocks by many non-specific illnesses, which can only be defined with the aid of accurate health records.

142. There are, in addition, a number of specific infectious and hereditary diseases which cause serious ill-health and lowered productivity when introduced into a flock previously free of them. Several are now known to be highly heritable and their control and eradication will depend on special recording and breeding programmes beyond the resources of individual flockmasters.

143. The reduction and elimination of these losses due to ill-health and disease will raise immediate productivity more rapidly than any programme of purely genetic improvement. In my experience it is neither practicable nor economically worthwhile to institute specialized techniques of genetic improvement until these health problems have been brought under control.

144. In the mind of a prospective purchaser the risk of introducing sheep of unknown health history into a valuable stud flock will normally outweigh the advantages of superior performance records.

145. I consider, therefore, that in stud flocks the control of disease and ill-health is essential and should be complementary to the improvement of their genetic capabilities.

146. I recommend that every encouragement should be given to the recording, definition and control of all causes of ill-health and low productivity, and that health recording under proper supervision should be considered essential in all stud flocks.

147. I would further recommend the establishment of an Advanced Scheme for Stud Flocks which would include such recording.

Appendix I

THE RELATIVE VALUES OF THE PRODUCTS OF THE SHEEP INDUSTRY

1. The following table shows the value of output of mutton and lamb and of wool produced in the United Kingdom.

	Value of mutton and lamb (£m.)	*Value of wool* (£m.)	*Total value of sheep products* (£m.)	*Value of wool as percentage of total value*
Pre-War Average	16·7	3·1	19·8	15·7
1946/47	26·1	4·3	30·4	14·1
1947/48	26·4	3·6	30·0	12·0
1948/49	32·4	5·4	37·8	14·3
1949/50	35·8	6·5	42·3	15·4
1950/51	37·7	6·7	44·4	15·1
1951/52	41·3	19·4	60·7	32·0
1952/53	51·1	15·2	66·3	22·9
1953/54	54·1	15·6	69·7	22·4
1954/55	58·4	16·5	74·9	22·0
1955/56	56·7	15·3	72·0	21·3
1956/57	62·9	15·2	78·1	19·5
1957/58	70·9	16·5	87·4	18·9
1958/59	68·2	16·6	84·8	19·6
1959/60	77·8	17·3	95·1	18·2

Source: Output and Utilisation of Farm Produce in the United Kingdom

2. However, the relative importance to individual farmers of wool sales and sales of sheep differs with breeds and with systems of management. These differences are exemplified by the results of university surveys as follows:

a. *Arable flocks in the Eastern Counties of England*

Composition of receipts (based on a survey in 1955–57)

	per cent
Wool receipts	11
Lamb sales	74
Culled ewes	4
Guarantees	11
Total	100

The above figures relate to crossbred flocks, most of which were using down breeds of ram on half-bred ewes.

Source: "Sheep on the Arable Farm" by P. G. James, School of Agriculture, University of Cambridge.

b. *Hill flocks in Wales*

	Composition of receipts				
	1954/55	1955/56	1956/57	1957/58	1958/59
No. of flocks	65	65	29	29	29
	(Identical sample)			(Identical sample)	
	%	%	%	%	%
Ewes	32	29	33	34	20
Wethers	10	9	6	7	8
Lambs	29	33	37	34	46
Rams	5	4	2	3	3
Wool	24	25	22	22	24
	100	100	100	100	100

Source: Hill Sheep Survey. Department of Agricultural Economics, Aberystwyth.

c. *Hill flocks in the Highland area of Scotland*

	Composition of receipts				
	1952	1953	1954	1955	1956
No. of farms	29	29	35	35	34
	%	%	%	%	%
Ewes	18	17	16	16	17
Other sheep	6	5	5	4	3
Lambs	29	33	30	33	37
Rams	2	1	1	1	2
Unallocated deficiency payments and hill sheep subsidies	—	—	2	8	7
Wool	45	44	46	38	34
	100	100	100	100	100

d. *Hill and stock-rearing farms in Scotland outside the Highland area*

	Composition of receipts								
	1955			1956			1957		
	Hill farms		Stock-	*Hill farms*		Stock-	*Hill farms*		Stock-
	Bl'ckface	Cross	rearing	Bl'ckface	Cross	rearing	Bl'ckface	Cross	rearing
No. of Farms	10	4	11	10	4	11	9	5	11
	%	%	%	%	%	%	%	%	%
Ewes	18	10	9	19	14	8	20	12	9
Other sheep	2	2	6	2	3	6	3	6	8
Lambs	47	60	64	48	58	65	51	60	66
Rams	2	1	2	2	1	2	1	1	1
Unallocated deficiency payments	6*	4*	4*	6*	4*	5*	3	2	2
Wool	25	23	15	23	20	14	22	19	14
	100	100	100	100	100	100	100	100	100

* Including hill sheep subsidy.

Source: West of Scotland Agricultural College, Farm Financial Returns.

Appendix 2

AGE EFFECT ON FERTILITY OF EWES

1. The results of investigations show that during the breeding life of the ewe, fertility of mating increases as the ewe advances in age and then decreases; or increases, remains fairly constant for a number of lambings and then decreases.

2. The number of surviving lambs per lambing increases with advancing age of ewes up to a maximum at about 4 to 5 years old.

3. Evidence to show the variation in prolificacy with the age of ewes for both hill and lowland flocks is given in the following tables.

4. In respect of Table 2, the performance of older ewes appears somewhat erratic. The reason for this is that, with advancing age, increasing numbers of ewes left the flocks and, consequently, the sample changed.

TABLE 1

LOWLAND FLOCK—BREED: CLUN FOREST

Performance of 147 ewes lactation by lactation
First lactation refers to ewes lambing at twelve months old

First lactation performance		Second lactation performance		Third lactation performance		Fourth lactation performance		Fifth lactation performance	
Born	Reared	Born	Reared	Born	Reared	Born	Reared	Born	Reared
1·11	0·81	1·73	1·64	1·88	1·76	1·92	1·74	1·89	1·76

Source: O. H. Colburn, Esq., Crickley Barrow, Northleach, Gloucestershire

TABLE 2

HILL FLOCK—BREED: SCOTCH BLACKFACE

Number of lambs born and average birth weights by year and age of dam

Year Ewe age	Total ewes at tupping	No. of ewes at lambing			Av. birth wt. (lb.)		Total lambs born	
		Dead, barren or aborted	Producing singles	Producing twins	Singles	Twins	No.	as % ewes tupped
2	396	129	256	11	6·15	4·50	278	70·2
3	341	75	259	7	6·70	4·32	273	80·1
1954 4	352	76	263	13	7·16	5·32	289	82·1
5	340	74	237	29	7·51	5·19	295	86·8
6	142	27	103	12	7·61	4·64	127	89·4
All ages	1,571	381	1,118	72	6·93	5·02	1,262	80·3
2	398	151	242	5	5·66	3·58	252	63·3
3	340	94	241	5	6·07	4·05	251	73·8
1955 4	306	83	220	3	6·49	4·33	226	73·9
5	312	90	217	5	6·62	5·38	227	72·8
6	241	72	157	12	6·47	4·94	181	75·1
All ages	1,597	490	1,077	30	6·25	4·58	1,137	71·2
2	380	57	320	3	6·61	5·27	326	85·8
3	359	49	292	18	7·42	5·24	328	91·4
1956 4	311	52	238	21	7·52	5·29	280	90·0
5	267	54	200	13	7·69	5·36	226	84·6
6	265	60	192	13	7·66	5·27	218	82·3
All ages	1,582	272	1,242	68	7·32	5·28	1,378	87·1
2	355	61	280	14	7·44	5·11	308	86·8
3	355	44	282	29	8·20	5·56	340	95·8
1957 4	319	46	226	47	8·31	6·00	320	100·3
5	272	30	205	37	8·30	6·25	279	102·6
6	219	224	169	26	8·22	5·92	221	100·9
All ages	1,520	405	1,162	153	8·05	5·87	1,468	95·8

Source: Animal Breeding Research Organisation, Agricultural Research Council, Edinburgh.

TABLE 3

Prolificacies of young and older ewes

BREED: SUFFOLK

The average litter size (ALS) i.e., number of lambs dead and live-born per ewe lambing to term of first crop and later crop ewes, in one pure-bred lowland flock for the period 1947–59.

Ewes lambing in	First crop		Later crops	
	No.	ALS.	No.	ALS.
1947	47	1·40	101	1·54
1948	37	1·35	133	1·49
1949	42	1·40	130	1·48
1950	28	1·53	125	1·55
1951	42	1·30	119	1·40
1952	51	1·27	119	1·49
1953	47	1·38	119	1·51
1954	35	1·37	121	1·51
1955	49	1·59	120	1·54
1956	54	1·54	135	1·65
1957	56	1·46	113	1·55
1958	81	1·50	112	1·57
1959	59	1·68	133	1·71

This flock is a ram-breeding flock not breeding from lambs. First crop ewes lamb at 2 years old.

Source: H. B. Parry, Esq., M.A., M.R.C.V.S.,
Director—Oxford Sheep Improvement Scheme.

Appendix 3

THE WISCONSIN SHEEP IMPROVEMENT PROGRAMME

1. This voluntary scheme was started by the University of Wisconsin in 1949 to improve the sheep in Wisconsin in economically important traits.

2. The information recorded for each ewe includes her age, weight at birth and at four months and the weight and quality of her fleece. Similar information is recorded for her lambs.

3. The university receives the record cards from each co-operating farmer and calculates an index for each ewe and ewe lamb. The cards are then returned to the farmer with a list of the ewes and ewe lambs of low and high indexes respectively. The farmer is advised to dispose of ewes in his flock with obvious defects, and then to cull the remainder by replacing ewes with low indexes by ewe lambs with high indexes. The farmer is also shown, at the end of each season, how average results in his flock compare with average results for all flocks in the scheme.

4. a. The ewe index is calculated as:
   2·8× fleece weight (lb)+the weight of the ewe's lamb adjusted to 120 days of age. If twins are reared, their average weight is used and 21 points are added. If twins are born but only one of them is reared, 6 points are added.

   b. The lamb index is calculated as:
   3× side staple length (cm)+the weight of the lamb adjusted to 120 days of age. Seven points are added if the lamb was born as a twin and reared as a single and 14 points if it was born and reared as a twin.

5. Results to date are shown in the following table:

	Number of flocks in scheme	Number of ewes indexed	Per cent of lambs that are twins	Average lamb weight at 4 months (lb)		Average weight (lb) of lamb per ewe at 4 months	Average fleece weight (lb) of ewes
				Single	Twin		
1950	40	1,282	52	63	58	83	8·5
1951	70	2,669	54·6	65	59	84	8·3
1952	114	3,726	54·6	62	57	76	7·9
1953	101	3,578	58·7	67	61	85	8·3
1954	134	4,102	52·5	67	60	82	8·4
1955	120	4,100	58·3	68	60	83	8·1
1956	96	3,988	57·5	67·3	61	84·9	8·2
1957	98	3,525	58·2	71·1	65·1	89·5	7·8
1958	150	4,752	59·9	73·3	67·9	95·0	7·6
1959	131	4,096	60·7	73·6	68·8	96·8	8·2

Pounds of lamb per ewe for years 1950–52 based on average of farm averages; after 1953 based on total pounds of lamb divided by number of ewes in programme.

EWE RECORD

No. of Ewe

NAME

BREED

EAR No.

DATE OF BIRTH

PAT. GRAND SIRE

MAT. GRAND SIRE

SIRE

PAT. GRAND DAM

DAM

MAT. GRAND DAM

RECORD OF PROGENY AND OTHER REMARKS

Year	19	19	19	19	19	Space for totals, averages, lifetime performance, etc.
Ram used						
Lambing date						
Sex of lamb(s)						
Identification No. of lambs						
Weight at weaning						
Fleece weight of ewe (lb)						
Fleece defects						
Other Notes 1. Foster/Mother/Lamb 2. How lamb(s) disposed of 3. Health History 4. Treatment 5.						

Appendix 5

EWE RECORD

No. of Ewe

NAME
BREED
EAR No.
DATE OF BIRTH

PAT. GRAND SIRE
MAT. GRAND SIRE

SIRE
PAT. GRAND DAM
DAM
MAT. GRAND DAM

RECORD OF PROGENY AND OTHER REMARKS

Year	19	19	19	19	19	Ewe index figure*	Space for totals, averages, lifetime performance, correction factors, etc.
Ram used							
Lambing date							
Sex of lamb(s)							
Identification of lambs							
Weight A. Birth B. C.							

Fleece weight (lb)								
Carcases								
Other Notes 1. Foster/Mother/ Lamb 2. Health history 3. Treatment 4. 5.								

**Example of Ewe Index*

$$\frac{\textit{Weaning Wt. of Lamb—Birth Wt. of Lamb}}{\text{No. of days from birth to weaning}} \times 100$$

Footnotes

1. *Examples of correction factors*

For male singles add	0·0 lb
For female singles add	7·0 lb
For male twins add	14·0 lb
For female twins add	20·0 lb
For 2 tooth gimmer's male lambs add	0·0 lb
For Hogg's lambs add	11·0 lb
For Ewe's lambs deduct	4·0 lb

2. Three spaces have been allocated for weights. It is suggested that the first space be used for birth weights and the other two to be used at the discretion of the breeder.

EXAMPLE OF A BREEDING SCHEME SUITABLE FOR THE IMPROVEMENT OF A FLOCK OF 296 EWES PRODUCING SIRES OF CROSS-BRED EWES

BY DR. J. W. B. KING, ANIMAL BREEDING RESEARCH ORGANIZATION, AGRICULTURAL RESEARCH COUNCIL

The following plan is suggested as an example of a scheme where a rapid turnover of generations is employed. It would be suitable for those characters of the ewe, such as number of lambs reared and their weight, which can be measured at or before weaning. No consideration has been paid to the cost of the scheme.

In the first year eight rams are each mated to 15 ewe lambs and 15 one-shear ewes. From each ram 12 daughters are kept to enter the flock in the next year.

In the second year the same eight rams are used again but only given 7 two-shear ewes each. From these "old" ewes all ram lambs are left entire as potential sires of the next generation. At the end of the summer the 8 new rams would be chosen on the combined basis of:

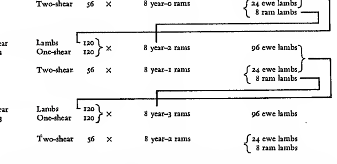
a. progeny test results of their sires as measured by the performance of 12 ewe lambs (or the half-sister performance);

b. three lambing records of their dams.

Meanwhile in the second year a completely new panel of 8 rams are each mated to 15 ewe-lambs and 15 one-shear ewes. The 120 ewe-lambs used would comprise 8×12=96 daughters of the pervious panel of rams plus 24 ewe-lambs from two-shear ewes. There are thus two panels of rams in operation.

The selection of females is straightforward. After two lamb crops half the ewes are culled on these two records. The 24 ewe lambs are chosen, like their brothers, on half sister and dam's performance.

The flow of flock replacements is as follows:



	Ewes			*Rams*	*Progeny*
Year 1	Lambs	120	×	8 year-1 rams	8×12=96 ewe lambs
	One-shear	120			
	Two-shear	56	×	8 year-0 rams	24 ewe lambs 8 ram lambs
Year 2	Lambs	120	×	8 year-2 rams	96 ewe lambs
	One-shear	120			
	Two-shear	56	×	8 year-1 rams	24 ewe lambs 8 ram lambs
Year 3	Lambs	120	×	8 year-3 rams	96 ewe lambs
	One-shear	120			
	Two-shear	56	×	8 year-2 rams	24 ewe lambs 8 ram lambs

The recurrent problem of inbreeding has to be faced. In this plan at least 2 sires of each 8 would be represented by sons, i.e., 4 sire "lines" in all. Sometimes more than 2 sires of each 8 would be represented, as on occasion exceptional performance by the dam would outweigh a moderate progeny test result on the sire.

EXAMPLE OF A BREEDING SCHEME SUITABLE FOR THE IMPROVEMENT OF A "SELF-CONTAINED" FLOCK OF 280 EWES PRODUCING ITS OWN REPLACEMENTS AS WELL AS FAT LAMB

BY OSCAR COLBURN, CRICKLEY BARROW, NORTHLEACH, GLOS.

The first necessity is to record the performance of individual females and to find a way of comparing the relative performance of contemporary females under identical conditions. Our method of doing this is to compare the *total* liveweight gain per day of *all* the lambs reared by a ewe with the average of those of her contemporaries that have reared twins in that year. For example, consider the case of twin lambs that have each averaged a liveweight gain from birth to 12 weeks of 0·70 lb per day; for our purposes the total liveweight gain of both lambs per day is multiplied by 100 and called a Ewe Index figure of 140. Similarly, if a ewe reared a single lamb under the same conditions, with a liveweight increase of 0·85 lb per day, the Index Figure is 85. This involves keeping contemporaries under identical conditions, and weighing their lambs at birth and an average of twelve weeks. A calculation is made of the average Index Figure for ewes that have reared twins in any given year. A comparison is then made between the performance of each individual in that age group and the average twin index, when a useful relative measure of both prolificacy and milking capacity is readily obtained.

Fifty-two home-bred hoggetts a year are brought into the flock as replacements and each of these females is compared with its contemporaries in this way over a period of five lactations. At the end of the fifth lactation a drastic culling takes place. Only those animals which have *reared* at least 9 lambs in 5 years (including their year as a hoggett) and also have milked better than their contemporaries in each lactation are retained for further use. These animals are then passed to the so-called "elite" flock where they are used for ram breeding.

Having found a satisfactory way of recording the performance of ewes, it then becomes possible to use that information to progeny test rams. Four rams are tested each year for transmission of prolificacy, milking capacity and growth rate. It takes three years to complete a progeny test on a group of rams. The four rams under test are mated with ewes in the middle section of the flock; that is, ewes in their third, fourth and fifth lactations. Each ram is mated to equal numbers of ewes of similar age. Within each age group effort is made to see that each ram is mated to ewes of equally good milking capacity as measured by the average of their previous recorded lactations. With some 50 ewes in each age group, there are 150 ewes to be divided between 4 rams. Each ram, therefore, is mated to some 35 ewes as equally matched for performance as is humanly possible.

At mating time each ram is left with his particular bunch of ewes for 34 days, when all the rams are taken up and the ewes are put together in one large bunch where they remain under identical conditions until their lambs are weaned the following summer. Their lambs are weighed at birth, at 5 weeks and 12 weeks. By comparing the average growth rates of the different bunches of lambs it is easy to see which sire is transmitting the highest growth rate. Singles, twins and triplets are compared separately. Thus growth rate is decided in the first year. Wether lambs from this part of the flock are graded separately, and a comparison is made of the carcasses sired by the four rams being tested. Carcass quality is the fourth thing to be considered when the final assessment of the value of the sires is made.

At the end of the first season, 13 daughters of each of the four rams are selected. These are brought into the flock as replacements that autumn and the bunch of 52 hoggetts are all served by one ram and are kept under identical conditions until their lambs are weaned the following summer—that is, second year of the sires' test, their own first lactation. Conditions are identical, the sire is identical, the variable factor this time is the four bunches of daughters. A simple measure of prolificacy is made and the difference in average growth rate of their lambs shows clearly which bunch of daughters are the best milkers.

The performance of the daughters groups in their first lactation provides a good indication of what may happen in subsequent years, but accuracy is ensured by again mating the same bunch of daughters to one ram in their second lactation—that is the third year of the sires' test. At the end of this third year a clear picture of the value of the four sires is obtained. Prolificacy is felt to be the most valuable followed by milking capacity, growth rate and finally carcass quality.

Having decided on the most valuable ram of the group, he is then mated to ewes in the "elite" flock for the production of ram lambs. In the fourth year four sons of the successful ram are put into test. In this way proven rams are being mated to proven ewes for the production of future sires and the system ensures cumulative improvement from year to year.

As has been stated, it takes three years to test a group of rams. After using them in the first year, they are withdrawn from use until their performance has been established. In the second year, four different rams are put into test and mated with the middle-aged ewes and in the third year, four different rams again. Each group is compared only within itself and not with the others. This means that three distinct blood lines are maintained within the flock at any one time and that we are triple-crossing three lines of sheep which are being progeny tested at each stage for the possession and transmission of desirable qualities. A system such as this is self-perpetuating and should lead to steady improvement in prolificacy, milking capacity and growth rate even though these characteristics are inherited at a low rate.

Appendix 8

EXAMPLE OF A BREEDING SCHEME SUITABLE FOR IMPROVEMENT OF A FLOCK OF SOME 210 EWES PRODUCING FAT LAMB SIRES

BY OSCAR COLBURN, CRICKLEY BARROW, NORTHLEACH, GLOS.

The characteristics that require development in a flock devoted to the production of fat lamb sires are growth rate and carcass quality. With rigorous limitation of objectives rapid progress may be expected from a breeding scheme that is devoted to improvement of these two characteristics.

Ewe recording in this type of flock can be relatively simple, since prolificacy and milking capacity are only of secondary interest. The essential thing is to differentiate between recording the milking capacity of the ewes and the growth rate of their offspring. A measure of the rate at which the lambs grow will be a reflection of the milking capacity of the mother rather than the inherent capacity of the lamb to put on weight. For this reason lamb growth rates are only of interest when averaged and related to sire influence. In a flock of this kind, therefore, although the lambs are weighed at birth and 12 weeks, the information is only of use when progeny testing sires. A particularly heavy lamb does not signify that its mother is an efficient producer of lambs with a high growth rate. It merely means that she happens to be a good milker and as such may even be an undesirable mother for a fat lamb sire. The only progeny measurement which can be of value in assessing a ewe is individual carcass appraisal of its lamb at 12 weeks of age.

In a flock producing fat lamb sires, ram lambs can be performance tested in their first year. After this preliminary weeding-out process, those of them that are actually used in the flock can be progeny tested by comparing the growth rate of their offspring from 0–12 weeks in the following year, and also by a carcass appraisal of their lambs at that time.

The sort of organization that might be required in a flock of some 210 ewes (including ewe lambs) will be readily apparent. The composition of the flock may well be as follows:

50 ewe lambs	(These may be bred from or not in their first year according to the inclination of the flockmaster concerned.)
40 second lactation ewes 40 third lactation ewes	These groups are mated to four rams to be tested each year. The lambs resulting from these matings are slaughtered and their carcasses appraised.
80 ewes older than 3rd lactation.	This group is mated to the two most successful sires in each year's progeny test. All their sons are performance tested. Their daughters are used for flock replacements.

The sequence of events is as follows. Lambing probably takes place in January or February. After weaning at approximately 12 weeks, all the ram lambs are retained from ewes in the oldest age group. These ram lambs are performance tested for the next 16 weeks. As a result of this test the four most successful ram lambs are chosen and are mated to the 80 ewes in the second and third lactations. The remainder are sold. Each of the four rams that are retained are mated to 10 second lactation and 10 third lactation ewes, and assuming a lambing percentage of 125, some 25 lambs by each sire would be born the following spring. These lambs would be weighed at birth and at 12 weeks. A simple measure of the average weight gain of each of the four groups indicates which of the four sires was producing the fastest growing lambs. At 12 weeks all these lambs are slaughtered and the carcasses appraised.

As a result of these tests on growth rate and carcass quality, the two best rams of the four originally tested are selected as sires for use within the flock. In the second autumn these are mated to the 80 older ewes for the production of sons to be similarly tested the following year. The complete performance and progeny test takes two years. Two distinct groups of sires are therefore to be used, each group being tested alternately.

One of the differences between a breeding scheme of this kind and common practice in this type of flock is that on this system ram lambs for sale are retained from only half the ewe flock. Normally every ram lamb of suitable "type" is sold. It is felt that the advantages of this system would eventually outweigh the financial advantages of selling every male as a crossing ram.

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SHEEP RECORDING AND PROGENY TESTING

Correction

Page 2, paragraph 5, second line: For "rams" read "men".

Ministry of Agriculture, Fisheries and Food. November, 1961.

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